

occurs no substantial response to the magnetic field.

When conventional antiferromagnetic layers of NiO or FeMnCr are used, the constant  $J$  could not be obtained at 200°C. On the other hand, when an antiferromagnetic layer of CrMnPt having a thickness of 30 nanometers, the resistance change rate is lower than that in conventional pinned magnetic layers having a single-layered structure, and the layer of CrMnPt of that type is unfavorable.

As in Table 7 showing the data of conventional pinned magnetic layers having a single-layered structure, PtMn gives high  $H_{UA}^*$  when its thickness is at least 20 nanometers but its resistance change rate falls between 6.4 and 6.7 % and is relatively low.

As opposed to those, in the samples of the invention shown in Table 6 in which the antiferromagnetic layer is of any of IrMn, RhMn, RhRuMn, PtMn, NiMn or CrMnPt having a thickness of at most 20 nanometers,  $H_{UA}^*$  at 200°C is at least 200 Oe, or that is, these samples have excellent thermal stability. In addition, the resistance change rate in those samples is comparable to or higher than that in the conventional samples where the pinned magnetic layer has a single-layered structure. In the invention, the lowermost limit of the thickness of the antiferromagnetic layer is preferably at least 3 nanometers.

Fig. 19 is a graph of the angle of movement of the

magnetization of the multi-layered, pinned magnetic layer of spin valve films of the invention with  $H_{UA}^*$  of 200 Oe and that of the single-layered, pinned magnetic layer of conventional spin valve films with  $H_{UA}$  of 500 Oe, versus time, in the presence of a bias field of 200 Oe at 200°C perpendicular to the direction of the pinned magnetization. As in Fig. 19, it is understood that the time-dependent change at 200°C in the pinned magnetization in the spin valve films of the invention is smaller than that in the pinned magnetization in the conventional spin valve films where the pinned magnetic layer has a single-layered structure, even though  $H_{UA}^*$  at 200°C in the former is 200 Oe and is smaller than that in the latter of being 510 Oe. This means that the spin valve films of the invention are stable.

The resistance change rate in the spin valve films of the invention where the antiferromagnetic layer is of an Mn-rich,  $\gamma$ -Mn based antiferromagnetic material such as IrMn, RhMn or RhRuMn and has a thickness of at most 10 nanometers is larger than that in the conventional spin valve films incorporating a single-layered, pinned magnetic layer. Those spin valve films of the invention are more preferred.

As in Table 6, the spin valve films of the invention with the antiferromagnetic layer having  $T_b$  of from 240 to 300°C have good thermal stability for the magnetization pinning. Therefore, in those spin valve films of the invention, since

both the ferromagnetic layer A and the ferromagnetic layer B could be saturated in the same direction by applying thereto a magnetic field larger than the coupling magnetic field of the antiferromagnetically coupling layer at around  $T_b$  to thereby freely control the magnetization direction of the pinned magnetic layer by the applied magnetic field, the intended magnetization pinning can be realized even at a temperature not higher than  $300^{\circ}\text{C}$  at which the diffusion between the antiferromagnetically coupling layer and the ferromagnetic layers A and B could be negligible.

In order to prevent the diffusion between the antiferromagnetically coupling layer and the ferromagnetic layers A and B and to retard the influences of the diffusion, it is desirable that the antiferromagnetically coupling layer has a thickness of larger than 0.8 nanometers and contains any of Ru, Rh, Cr, Ir or the like. For that purpose, it is effective to use a Co alloy such as CoFe for the ferromagnetic layers A and B and to make the level of the surface roughness of the antiferromagnetically coupling layer comparable to or lower than the thickness of the layer itself.

In the thermal treatment for settling the magnetization direction of the pinned magnetic layer, both the magnetic layers A and B must be saturated in the same direction. Therefore, if the ferromagnetic layers A and B are so thinned that their thickness is around 2 nanometers and when the